Alternative Turnarounds

Postconstruction Storm Water Management in New Development and Redevelopment

Description

Rather than having a fully paved cul-de-sac bulb, site designers can incorporate pervious circles with vegetation that reduce the site's overall impervious area

Alternative turnarounds are designs for end-of-street vehicle turnaround that replace cul-de-sacs and reduce the amount of impervious cover created in residential neighborhoods. Cul-de-sacs are local access streets with a closed circular end that allows for vehicle turnarounds. Many of these cul-de-sacs can have a radius of more than 40 feet. From a storm water perspective, cul-de-sacs create a huge bulb of impervious cover, increasing the amount of storm water runoff. For this reason, reducing the size of cul-de-sacs through the use of alternative turnarounds or eliminating them altogether can reduce the amount of impervious cover created at a site.

Numerous alternatives create less impervious cover than the traditional 40-foot cul-de-sac. These alternatives include reducing cul-de-sacs to a 30-foot radius and creating hammerheads, loop roads, and pervious islands in the cul-de-sac center.

Applicability

Alternative turnarounds can be applied in the design of residential, commercial, and mixed-use developments. Combined with alternative pavers, green parking, curb elimination, and other techniques, the total reduction to site impervious cover can be dramatic, reducing the amount of storm water runoff from the site. With proper designs, much of the remaining storm water can be treated on site.

Implementation

Sufficient turnaround area is a significant factor to consider in the design of cul-de-sacs. In particular, the types of vehicles entering into the cul-de-sac should be considered. Fire trucks, service vehicles, and school buses are often cited as examples for increased turning radii. However, research shows that some fire trucks are designed for smaller turning radii. In addition, many new larger service vehicles are designed using a tri-axle, and school buses usually do not enter individual cul-de-sacs.

Implementation of alternative turnarounds will also have to address local regulations and marketing issues. Communities may have specific design criteria for cul-de-sacs and other alternative turnarounds. Also, although cul-de-sacs are often featured as highly marketable, actual research on market preference is not widely available.

Limitations

Local regulations often dictate requirements for turnaround radii, and some of the alternatives may not be allowed by local codes. In addition, marketing perceptions may also dictate designs, particularly in residential areas. While changing local codes is no small effort, by initiating a local site planning roundtable, communities can change some of these regulations through a cluster ordinance or through a collective effort to review local codes to promote better site design.

Maintenance Considerations

If islands are constructed as part of a turnaround, these areas will need to be maintained. Kept as a natural area, the costs could be minimal. Bioretention areas will also require maintenance. The other options create less asphalt to repave, and maintenance will remain the same and cost less.

Effectiveness

In comparisons of several different turnaround options, hammerheads were found to create the least amount of impervious cover, as shown in Table 1.

Table 1. Impervious cover created by each turnaround option (Schueler, 1995)

Turnaround Option	Impervious Area (square feet)
40-foot radius	5,024
40-foot radius with island	4,397
30-foot radius	2,826
30-foot radius with island	2,512
Hammerhead	1,250

Costs

Since alternative turnarounds reduce the amount of impervious cover created, construction savings can be an incentive (asphalt costs \$0.50–\$1.00 per square foot in materials alone). Bioretention is estimated at \$6.40 per cubic foot, and while it costs more than providing naturally vegetated areas, it can help reduce overall storm water management costs.

Information Resources

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Alternative Pavers

Postconstruction Storm Water Management in New Development and Redevelopment

Description

Alternative pavers are permeable surfaces that can replace asphalt and concrete and can be used for driveways, parking lots, and walkways. From a storm water perspective, this is important because alternative pavers can replace impervious surfaces, creating less storm water runoff. The two broad categories of alternative pavers are paving blocks and other surfaces, including gravel, cobbles, wood, mulch, brick, and natural stone. While porous pavement is an alternative paver, as an engineered storm water management practice it is discussed in detail in the Porous Pavement fact sheet.

One type of alternative paver consists of a concrete lattice structure for support with grass growing in the void spaces (Source: Lo Gioco Landscaping, Inc., no date)

Paving Blocks

Paving blocks are concrete or plastic grids with gaps between them. Paving blocks make the surface more rigid and gravel or grass planted inside the holes allows for infiltration. Depending on the use and soil types, a gravel layer can be added underneath to prevent settling and allow further infiltration.

Other Alternative Surfaces

Gravel, cobbles, wood, and mulch also allow varying degrees of infiltration. Brick and natural stone arranged in a loose configuration allow for some infiltration through the gaps. Gravel and cobbles can be used as driveway material, and wood and mulch can be used to provide walking trails.

Applicability

Alternative pavers can replace conventional asphalt or concrete in parking lots, driveways, and walkways. At the same time, traffic volume and type can limit application. For this reason, alternative pavers for parking are recommended only for overflow areas. In residential areas, alternative surfaces can be used for driveways and walkways, but are not ideal for areas that require handicap accessibility.

Siting and Design Criteria

Accessibility, climate, soil type, traffic volume, and long-term performance should be considered, along with costs and storm water quality controls, when choosing paving materials. Use of alternative pavers in cold climates will require special consideration, as snow shovels are not practical for many of these surfaces. Sand is particularly troublesome if used with paving blocks, as the sand that ends up between the blocks cannot effectively wash away or be removed.

In addition, salt used to de-ice can also infiltrate directly into the soil and cause potential ground water pollution.

Soil types will affect the infiltration rates and should be considered when using alternative pavers. Clayey soils (D soils) will limit the infiltration on a site. If ground water pollution is a concern, use of alternative pavers with porous soils should be carefully considered.

The durability and maintenance cost of alternative pavers also limits use to low-traffic-volume areas. At the same time, alternative pavers can abate storm water management costs. Used in combination with other better-site-design techniques, the cumulative effect on storm water can be dramatic.

Limitations

Alternative pavers are not recommended for high-traffic volumes for durability reasons. Access for wheelchairs is limited with alternative pavers. In addition, snow removal is difficult since plows cannot be used, sand can cause the system to clog, and salt can be a potential pollutant.

Maintenance Considerations

Alternative pavers require periodic maintenance, and costs increase when the permeable surface must be restored.

Effectiveness

The most obvious benefit of utilizing alternative pavers includes reduction or elimination of other storm water management techniques. Applied in combination with other techniques such as bioretention and green parking, pollutant removal and storm water management can be further improved. (see Bioretention and Green Parking fact sheets for more information.)

Alternative pavers all provide better water quality improvement than conventional asphalt or concrete, and the range of improvement depends on the type of paver used. Table 1 provides a list of pavers and the range of water quality improvement achievable by different types of alternative pavers.

Table 1. Water quality improvement of various pavers (Source: BASMAA, 1997)

Material	Water Quality Effectiveness
Conventional Asphalt/ Concrete	Low
Brick (in a loose configuration)	Medium
Natural Stone	Medium
Gravel	High
Wood Mulch	High
Cobbles	Medium

Cost Considerations

The range of installation and maintenance costs of various pavers is provided in Table 2. Depending on the material used, installation costs can be higher or lower for alternative pavers than for conventional asphalt or concrete, but maintenance costs are almost always higher.

Table 2. Installation and maintenance costs for various pavers (Source: BASMAA, 1997)

Material	Installation Cost	Maintenance Cost
Conventional Asphalt/Concrete	Medium	Low
Brick (in a loose configuration)	High	Medium
Natural Stone	High	Medium
Gravel	Low	Medium
Wood Mulch	Low	Medium
Cobbles	Low	Medium

Reference

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BMP Inspection and Maintenance

Postconstruction Storm Water Management in New Development and Redevelopment

Description

Regular inspection and maintenance of storm water best management practices is important to ensure that the practices are functioning properly and to remove trash and organic debris

To maintain the effectiveness of postconstruction storm water control best management practices (BMPs), regular inspection of control measures is essential. Generally, inspection and maintenance of BMPs can be categorized into two groups—expected routine maintenance and nonroutine (repair) maintenance. Routine maintenance refers to checks performed on a regular basis to keep the BMP in good working order and aesthetically pleasing. In addition, routine inspection and maintenance is an efficient way to prevent potential nuisance situations (odors, mosquitoes, weeds, etc.), reduce the need for repair maintenance, and reduce the chance of polluting storm water runoff by finding and correcting problems before the next rain.

In addition to maintaining the effectiveness of storm water BMPs and reducing the incidence of pests, proper inspection and maintenance is essential to avoid the health and safety threats inherent in BMP neglect (Skupien, 1995). The failure of structural storm water BMPs can lead to downstream flooding, causing property damage, injury, and even death.

Applicability

Under the proposed Storm Water Phase II rule, owners and operators of small municipal separate storm sewer system (MS4) facilities would be responsible for implementing BMP inspection and maintenance programs and having penalties in place to deter infractions (USEPA, 1999). All storm water BMPs should be inspected for continued effectiveness and structural integrity on a regular basis. Generally, all BMPs should be checked after each storm event in addition to these regularly scheduled inspections. Scheduled inspections will vary among BMPs. Structural BMPs such as storm drain drop inlet protection may require more frequent inspection to ensure proper operation. During each inspection, the inspector should document whether the BMP is performing correctly, any damage to the BMP since the last inspection, and what should be done to repair the BMP if damage has occurred.

Siting and Design Considerations

In the case of vegetative or other infiltration BMPs, inspection of storm water management practices following a storm event should occur after the expected drawdown period for a given

BMP. This allows the inspector to see whether detention and infiltration devices are draining correctly.

Inspection checklists should be developed for use by BMP inspectors. Checklists might include each BMP's minimum performance expectations, design criteria, structural specifications, date of implementation, and expected life span. In addition, the maintenance requirements for each BMP should be listed on the inspection checklist. This will aid the inspector in determining whether a BMP's maintenance schedule is adequate or needs revision. Also, a checklist will help the inspector determine renovation or repair needs.

Limitations

Routine maintenance materials such as shovels, lawn mowers, and fertilizer may be easily obtained on short notice with little effort. Unfortunately, not all materials that may be needed for emergency structural repairs are obtained with such ease. Thought should be given to stockpiling essential materials in case immediate repairs must be made to safeguard against property loss and to protect human health.

Maintenance Considerations

It is important that routine maintenance and nonroutine repair of storm water BMPs be done according to schedule or as soon as a problem is discovered. Because many BMPs are rendered ineffective for runoff control if not installed and maintained properly, it is essential that maintenance schedules are maintained and repairs are made promptly. In fact, some cases of BMP neglect can have detrimental effects on the landscape and increase the potential for erosion. However, "routine" maintenance, such as mowing grasses, should be flexible enough to accommodate the fluctuations in need based on relative weather conditions. For example, more harm than good may be caused by mowing during an extremely dry period or immediately following a storm event.

Effectiveness

The effectiveness of BMP inspection will be a function of the familiarity of the inspector with each particular BMP's location, design specifications, maintenance procedures, and performance expectations. Documentation should be kept regarding the dates of inspection, findings, and maintenance and repairs that result from the findings of an inspector. Such records are helpful in maintaining an efficient inspection and maintenance schedule and providing evidence of ongoing inspection and maintenance.

Because maintenance work for storm water BMPs is usually not technically complicated (mowing, removal of sediment, etc.), workers can be drawn from a large labor pool. As structural BMPs increase in their sophistication, however, more specialized maintenance training might be needed to sustain BMP effectiveness.

Cost Considerations

Mowing of vegetated and grassed areas may be the costliest routine maintenance consideration (WEF, 1998). Management practices using relatively weak materials (such as filter fabric and wooden posts) may mean more frequent replacement and therefore increased costs. The use of more sturdy materials (such as metal posts) where applicable may increase the life of certain BMPs and reduce replacement cost. However, the disposal requirements of all materials should be investigated before BMP implementation to ensure proper handling after the BMP has become ineffective or when it needs to be disposed of after the site has reached final stabilization. Table 1 shows maintenance costs, specific activities, and schedules for several postconstruction runoff BMPs.

Table 1. Maintenance costs, activities, and schedules for urban management practices (Adapted from CWP, 1998)

Type of Practice	Management Practice	Annual Maintenance Cost (% of Construction Cost)	Maintenance Cost for a "Typical" Application	Maintenance Activity	Schedule
Detention/ Retention Practices	Ponds/ wetlands	3%–6%	$3,000 to $6,000	• Cleaning and removal of debris after major storm events; (>f rainfall) • Harvest vegetation when a 50% reduction in the original open water surface area occurs • Repair of embankment and side slopes • Repair of control structure	Annual or as needed
				• Removal of accumulated sediment from forebays or sediment storage areas when 60% of the original volume has been lost	5-year cycle
				• Removal of accumulated sediment from main cells of pond once 50% of the original volume has been lost	20-year cycle
	Dry Ponds	~1%	$1,200	See above	
	Wetlands	~2%	$3,800	See above	
Infiltration Facilities	Infiltration Trench	5%–20%	$2,300 to $9,000	• Cleaning and removal of debris after major storm events; (>2" rainfall) • Mowing and maintenance of upland vegetated areas • Sediment cleanout • Repair or replacing of stone aggregate • Maintenance of inlets and outlets	Annual or as needed
				• Removal of accumulated sediment from forebays or sediment storage areas when 50% of the original volume has been lost	4-year cycle
	Infiltration Basin	1%–10%	$150–$1,500	• Cleaning and removal of debris after major storm events; (>2" rainfall) • Mowing and maintenance of upland vegetated areas • Sediment cleanout	Annual or as needed
				• Removal of accumulated sediment from forebays or sediment storage areas when 50% of the original volume has been lost	3- to 5-year cycle

Table 1. (continued)

Type of Practice	**Management Practice**	**Annual Maintenance Cost (% of Construction Cost)**	**Maintenance Cost for a "Typical" Application**	**Maintenance Activity**	**Schedule**
Filtration Practices	Sand Filters	11%–13%	$2,200	• Removal of trash and debris from control openings • Repair of leaks from the sedimentation chamber or deterioration of structural components • Removal of the top few inches of sand, and cultivation of the surface, when filter bed is clogged	Annual or as needed
				• Clean out of accumulated sediment from filter bed chamber once depth exceeds approximately ½ inch, or when the filter layer will no longer draw down within 24 hours • Clean out of accumulated sediment from sedimentation chamber once depth exceeds 12 inches	3- to 5-year cycle
	Dry Swales, Grassed Channels, Biofilters	5%–7%	$200 to $2,000	• Mowing and litter/debris removal • Stabilization of eroded side slopes and bottom • Nurtient and pesticide use management • Dethatching swale bottom and removal of thatching • Discing or aeration of swale bottom	Annual or as needed
				• Scraping swale bottom and removal of sediment to restore original cross section and infiltration rate • Seeding or sodding to restore ground cover (use proper erosion and sediment control)	5-year cycle
	Filter Strips	$320/acre (maintained)	$1,000	• Mowing and litter/debris removal • Nutrient and pesticide use management • Aeration of soil on the filter strip • Repair of eroded or sparse grass areas	Annual or as needed
	Bioretention	5%–7%	$3,000 to $4,000	• Repair of erosion areas • Mulching of void areas • Removal and replacement of all dead and diseased vegetation • Watering of plant material	Biannual or as needed
				• Removal of mulch and application of a new layer	Annual

References

Center for Watershed Protection (CWP). 1998. *Costs and Benefits of Storm Water BMP's: Final Report 9/14/98.* Center for Watershed Protection, Ellicott City, MD.

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Ordinances for Postconstruction Runoff

Postconstruction Storm Water Management in New Development and Redevelopment

Description

The management of storm water runoff from sites after the construction phase is vital to controlling the impacts of development on urban water quality. The increase in impervious surfaces such as rooftops, roads, parking lots, and sidewalks due to land development can have a detrimental effect on aquatic systems. Heightened levels of impervious cover have been associated with stream warming and loss of aquatic biodiversity in urban areas. Runoff from impervious areas can also contain a variety of pollutants that are detrimental to water quality, including sediment, nutrients, road salts, heavy metals, pathogenic bacteria, and petroleum hydrocarbons.

An ordinance promotes the public welfare by guiding, regulating, and controlling the design, construction, use, and maintenance of any development or other activity that disturbs or breaks the topsoil or results in the movement of earth on land. The goal of a storm water management ordinance for postconstruction runoff is to limit surface runoff volumes and reduce water runoff pollutant loadings.

Applicability

These ordinances are applicable to all major subdivisions in a municipality. The size of the development to which postconstruction storm water management runoff control applies varies, but many communities opt for a size limit of 5,000 square feet or more. Applicability should be addressed in more detail in the ordinance itself. It is important to note that all plans must be reviewed by local environmental protection officials to ensure that established water quality standards will be maintained during and after development of the site and that postconstruction runoff levels are consistent with any local and regional watershed plans.

Several resources are available to assist in developing an ordinance. EPA's (2000) postconstruction model ordinance web site (*http://www.epa.gov/nps/ordinance/postcons.htm*) provides a model ordinance and examples of programs currently being implemented. In addition, the Stormwater Managers Resource Center (*http://www.stormwatercenter.net*), which was created by the Center for Watershed Protection (no date) and sponsored by the U.S. Environmental Protection Agency, provides information to storm water management program managers in Phase II communities to assist in meeting the requirements of the National Pollutant Discharge Elimination System Phase II regulations.

Siting and Design Considerations

The purpose of the postconstruction ordinance is to establish storm water management requirements and controls to protect and safeguard the general health, safety, and welfare of the public residing in watersheds within a jurisdiction. The following paragraphs provide the general language and concepts that can be included in your ordinance.

General Provisions

This section should identify the purpose, objectives, and applicability of the ordinance. The size of the development to which postconstruction runoff controls apply varies, but many communities opt for a size limit of 5,000 square feet or more. This section can also contain a discussion of the development of a storm water design manual. This manual can include a list of acceptable storm water treatment practices and may include the specific design criteria for each storm water practice. In addition, local communities should select the minimum water quality performance standards they will require for storm water treatment practices, and place them in the design manual.

Definitions

It is important to define the terms that will be used throughout the ordinance to assist the reader and prevent misinterpretation.

Permit Procedures and Requirements

This section should identify the permit required; the application requirements, procedures, and fees; and the permit duration. The intent of the permit should be to ensure that no activities that disturb the land are issued permits prior to review and approval. Communities may elect to issue a storm water management permit separate from any other land development permits required, or, as in this ordinance, to tie the issuing of construction permits to the approval of a final storm water management plan.

Waivers to Storm Water Management Requirements

This section should discuss the process for requesting a waiver and to whom this waiver would be applicable. Alternatives such as fees or other provisions for those requesting a waiver should be addressed as well.

General Performance Criteria for Storm Water Management

The performance criteria that must be met should be discussed in this section. The performance criteria can include the following:

- All sites must establish storm water practices to control the peak flow rates of storm water discharge associated with specified design storms and reduce the generation of storm water.

- New development may not discharge untreated storm water directly into a jurisdictional wetland or local waterbody without adequate treatment.

- Annual groundwater recharge rates must be maintained by promoting infiltration through the use of structural and non-structural methods.

- For new development, structural sewage treatment plants must be designed to remove a certain percentage of the average annual postdevelopment total suspended solids (TSS) load.

Basic Storm Water Management Design Criteria

Rather than place specific storm water design criteria into an ordinance, it is often preferable to fully detail these requirements in a storm water design manual. This approach allows specific design information to be changed over time as new information or techniques become available without requiring the formal process needed to change ordinance language. The ordinance can then require those submitting any development application to consult the current storm water design manual for the exact design criteria for the storm water management practices appropriate for their site. Topics in the manual can include minimum control requirements, site design feasibility, conveyance issues, pretreatment requirements, and maintenance agreements.

Requirements for Storm Water Management Plan Approval

The requirements for a storm water management plan to be approved should be addressed in this section. This can be accomplished by including a submittal checklist in the storm water design manual. A checklist is particularly beneficial because changes in submittal requirements can be made as needed without needing to revisit and later revise the original ordinance.

Construction Inspection

This section should include information on the notice of construction commencement, as-built plans, and landscaping and stabilization requirements.

Maintenance and Repair of Storm Water Facilities

Maintenance agreements, failure to maintain practices, maintenance covenants, right-of-entry for inspection, and records of installation and maintenance activities should be addressed in this section.

Enforcement and Penalties

This section should include information regarding violations, notices of violation, stop work orders, and civil and criminal penalties.

Limitations

Site inspections are required for a postconstruction storm water ordinance to be effective. In addition, an adequate staff must be available to review permit applications and proposed plans.

Maintenance Considerations

The operation and maintenance language in a storm water ordinance can ensure that designs facilitate easy maintenance and that regular maintenance activities are completed. In the "Maintenance and Repair of Storm Water Facilities" section of your ordinance, it is important to include language regarding a maintenance agreement, failure to maintain practices, maintenance covenants, right-of-entry for inspection, and records of installation and maintenance activities.

Effectiveness

If a storm water management ordinance for existing development is properly implemented and enforced, the community can effectively achieve the following:

- Minimize increases in storm water runoff from any development to reduce flooding, siltation, and streambank erosion and to maintain the integrity of stream channels.

- Minimize increases in nonpoint source pollution caused by storm water runoff from development that would otherwise degrade local water quality.

- Minimize the total annual volume of surface water runoff that flows from any specific site during and following development so as not to exceed the predevelopment hydrologic regime to the maximum extent practicable.

- Reduce storm water runoff rates and volumes, soil erosion, and nonpoint source pollution, wherever possible, through storm water management controls and ensure that these management controls are properly maintained and pose no threat to public safety.

Cost Considerations

Municipalities that implement and enforce postconstruction ordinances must budget for the drafting and enforcement of the regulation.

References

Center for Watershed Protection (CWP). No date. Stormwater Manager's Resource Center. [www.stormwatercenter.net]. Accessed May 24, 2001.

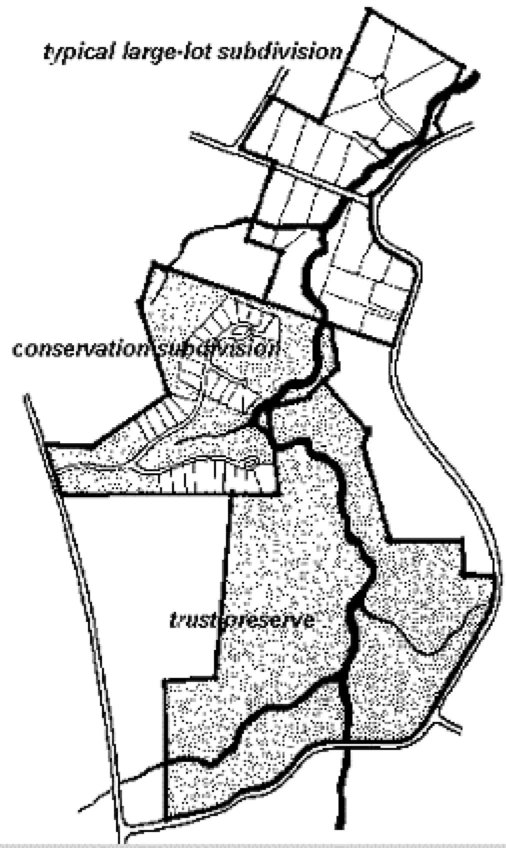
USEPA. 2000. *Model Ordinances to Protect Local Resources: Postconstruction Controls.* U.S. Environmental Protection Agency, Washington, DC.[www.epa.gov/nps/ordinance/postcons.htm]. Accessed October 3, 2000. Last updated July 12, 2000.

Zoning

Postconstruction Storm Water Management in New Development and Redevelopment

Description

Zoning is a classification scheme for land use planning. Zoning can serve numerous functions and can help mitigate storm water runoff problems by facilitating better site designs. By correctly applying the right zoning technique, development can be targeted into specific areas, limiting development in other areas and providing protection for the most important land conservation areas.



Property boundaries differ widely between traditional large-lot zoning, which maximizes the acreage of individual properties, and conservation zoning, which maximizes the amount of shared open space (Source: Arendt, 1996)

There are numerous types of zoning techniques for better site design, including watershed-based zoning, overlay zoning, floating zones, incentive zoning, performance zoning, urban growth boundaries, large lot zoning, infill/community redevelopment, transfer of development rights, and limiting infrastructure extensions. Table 1 describes each of these zoning techniques and its utility.

Applicability

The type of zoning to apply will depend on management goals. If water or land quality is a primary goal of the zoning technique, then watershed-based zoning can provide a comprehensive approach. At the same time, incentive zoning, performance zoning, and transfer of development rights can be used as protection measures for specific conservation areas.

Implementation

Watershed-Based Zoning: Watershed-based zoning can employ a mixture of land use and zoning options to achieve desired results. A watershed-based zoning approach should include the following nine steps:

- Conduct a comprehensive stream inventory.
- Measure current levels of impervious cover.
- Verify impervious cover/stream quality relationships.
- Project future levels of impervious cover.

Table 1. Zoning techniques (Source: Caraco et al., 1998)

Land Use Planning Technique	**Description**	**Utility as a Watershed Protection Technique**
Watershed-Based Zoning	Watershed and subwatershed boundaries are the foundation for land use planning.	Protects receiving water quality on the subwatershed scale by relocating development out of particular subwatersheds.
Overlay Zoning	Superimposes additional regulations or specific development criteria within specific mapped districts.	Requires development restrictions or allows alternative site design techniques in specific areas.
Impervious Overlay Zoning	Specific overlay zoning that limits total impervious cover within mapped districts.	Protects receiving water quality at both the subwatershed and site level.
Floating Zones	Applies a special zoning district without identifying the exact location until land owner specifically requests the zone.	Obtains proffers or other watershed protective measures that accompany specific land uses within the district.
Incentive Zoning	Applies bonuses or incentives to encourage creation of amenities or environmental protection.	Encourages development within a particular subwatershed or to obtain open space in exchange for a density bonus at the site level.
Performance Zoning	Specifies a performance requirement that accompanies a zoning district.	Requires additional levels of performance within a subwatershed or at the site level.
Urban Growth Boundaries	Establishes a dividing line that defines where a growth limit is to occur and where agricultural or rural land is to be preserved.	Used in conjunction with natural watershed or subwatershed boundaries to protect specific water bodies.
Large Lot Zoning	Zones land at very low densities.	Decreases impervious cover at the site or subwatershed level, but may have an adverse impact on regional or watershed imperviousness.
Infill/Community Redevelopment	Encourages new development and redevelopment within existing developed areas.	Used in conjunction with watershed-based zoning or other zoning tools to restrict development in sensitive areas and foster development in areas with existing infrastructure.
Transfer of Development Rights (TDRs)	Transfers potential development from a designated "sending area" to a designated "receiving area."	Used in conjunction with watershed-based zoning to restrict development in sensitive areas and encourage development in areas capable of accommodating increased densities.
Limiting Infrastructure Extensions	A conscious decision is made to limit or deny extending infrastructure (such as public sewer, water, or roads) to designated areas to avoid increased development in these areas.	A temporary method to control growth in a targeted watershed or subwatershed. Usually delays development until the economic or political climate changes.

- Classify subwatersheds-based on stream management "templates" and current impervious cover.
- Modify master plans/zoning to correspond to subwatershed impervious cover targets and other management strategies identified in Subwatershed Management Templates.
- Incorporate management priorities from larger watershed management units such as river basins or larger watersheds (see discussion later in this fact sheet).
- Adopt specific watershed protection strategies for each subwatershed.
- Conduct long-term monitoring over a prescribed cycle to assess watershed status.

Overlay Zoning: The advantage of overlay zones is that specific criteria can be applied to isolated areas without the threat of being considered spot zoning. Overlay districts are not necessarily restricted by the limits of the underlying base zoning. An overlay zone may take up only a part of an underlying zone or may even encompass several underlying zones. Often the utilization of an overlay zone is optional.

Impervious Overlay Zoning: This type of overlay zoning limits future impervious areas. The environmental impacts of future impervious cover are estimated and a limit is set on the maximum imperviousness within a given planning area. Site development proposals are then reviewed in the context of an imperviousness cap. Subdivision layout options must then conform to the total impervious limit of the planning area.

Floating Zones: Normally, a parcel of land will not qualify for the application of the floating zone district unless it is large enough to allow the buffering of its development from the surrounding area. It is important to note that the existence of a floating zone district does not automatically grant rezoning to each landowner whose property complies with the prescribed conditions. Each property owner must have his or her application for rezoning reviewed and approved by the local governing body to determine if it is consistent with a comprehensive development plan.

Incentive Zoning: This planning technique relies on bonuses or incentives for developers to encourage the creation of certain amenities or land use designs. A developer is granted the right to build more intensively on a property or given some other bonus in exchange for an amenity or a design that the community considers beneficial. Developers stand to gain an increase in profits from the more intensive use of the property, while a community might use incentive zoning to promote more compact development, encourage open space designs, or generate other desired amenities such as trails, parks, or totlots.

Performance Zoning: Performance zoning is a flexible approach that has been employed in a variety of fashions in several different communities across the country. Some performance factors include traffic or noise generation limits, lighting requirements, storm water runoff quality and quantity criteria, protection of wildlife and vegetation, and even architectural style criteria.

Urban Growth Boundaries: Urban growth boundaries are sometimes called development service districts and include areas where public services are already provided (e.g., sewer, water, roads, police, fire, and schools). The delineation of the boundary is very important. Several important issues to consider in establishing an urban growth boundary include the following:

- Public facilities and services must be nearby and/or can be provided at reasonable cost and in a specific time frame.
- A sufficient amount of land to meet projected growth over the planning period must be provided.
- A mix of land uses must be provided.
- The potential impact of growth within the boundary on existing natural resources should be analyzed.
- The criteria for defining the boundary needs to be fair and should consider natural features (versus man-made features) wherever possible. The use of watershed boundaries as the urban growth boundary is one such natural feature.

<u>Large Lot Zoning:</u> Although large lot zoning does tend to reduce the impervious cover and therefore the amount of storm water runoff at a particular location, it also spreads development over vast areas. The road networks required to connect these large lots can actually increase the total amount of imperviousness created for each dwelling unit (Schueler, 1995). In addition, large lot zoning contributes to regional sprawl. Sprawl-like development increases the expense of providing community services such as fire protection, water and sewer systems, and school transportation.

<u>Infill/Community Redevelopment</u>: Infill and redevelopment can be employed in either large or small projects. Some of the existing impediments to more widespread implementation of these types of projects include the existing condition of a potential redevelopment site in terms of environmental constraints, the restrictive nature of many land use regulations, and pressing social and economic issues. Local governments may need to modify local zoning or building codes to make infill and redevelopment a more inviting attraction to developers. In addition, citizen involvement has been demonstrated to be a vital catalyst for leveraging funding or revising codes. Furthermore, lending institutions must be progressive in their view of funding infill and redevelopment projects. One possibility is to partner with local governments or community organizations.

<u>Transfer of Development Rights (TDRs)</u>: The principle of TDRs is based on the premise that ownership of land entails certain property rights. While some of these rights may be restricted by zoning, building codes, and environmental constraints, landowners are "entitled" to use their land for the "highest and best use." TDRs are based on a market-driven incentive program where it is possible to sell development potential (zoned density) without buying or selling land. Landowners in preservation areas are compensated for lost development potential , while conventional down-zoning deprives landowners of this potential value.

Limitations

Some zoning techniques may be limited by economic and political acceptance and should be evaluated on these criteria as well as storm water management goals.

Maintenance Considerations

Some maintenance issues to consider for the long term are the following:

- What are the most economically and politically acceptable zoning technique(s) that can be used to shift or reduce impervious cover among the subwatersheds?

- How accurate are the estimates of the amount and location of future impervious cover in the watershed? Are better projections needed?

- Will future increases in impervious cover create unacceptable changes to a watershed and/or subwatershed?

- Which subwatersheds appear capable of absorbing future growth in impervious cover?

Effectiveness

There are numerous case studies of performance-based zoning used in different communities. Some of these examples are summarized in Table 2.

Table 2. Case examples of performance-based zoning (Source: Porter et al., 1991)

Location	Performance Zoning Provisions	Notes
Fort Collins, Colorado	Planned Unit Development (PUD) options are applied to all parcels in city. Developers may choose conventional zoning or the optional PUD. PUD proposals must meet a point value for an absolute criterion and a relative criterion.	Applications are discussed at a conceptual stage where suggestions are made to improve scores. The local planning board has quite a bit of latitude to use discretion to require special conditions.
Largo, Florida	The Land Use Plan defines uses and densities. Four overlay "policy"districts (environmental conservation, management, redevelopment, and downtown) define general standards and prohibited uses. Each land use within a policy district falls into a one of three classes (allowable, allowable with special mitigating measures, or prohibited).	A variety of uses are permitted within the 4 policy districts when applying the special mitigating measures. The city also has a five-tiered system of review and approval that facilitates fast reviews for many common applications and a more involved process for projects that require mitigation.
Hardin County, Kentucky	The land development ordinance allows agricultural and single family uses by right. All other uses must be evaluated by a three-step process. At the first step, the agricultural and development potential is evaluated using a point system. If the site scores a minimum threshold value, than it moves onto the second step, a compatibility assessment. The final step involves typical review of subdivision standards and requirements.	The program places a special emphasis on preserving agricultural uses. The process involves a unique feature that calls on citizen consensus for each step. This decision making process might be considered highly discretionary, but with a widespread interest by most Hardin County citizens in seeing development proceed, there have been few complaints.
Bath Charter Township, Michigan	The township's ordinance provides five zoning districts: two traditional districts for rural, low-density residential; and three applied to existing settlements/expected development corridor. These three districts allow a range of uses either "by right" or with special permits for certain uses.	The ordinance is a compromise between complex, inflexible zoning and no zoning at all. The process allows for extensive review and individual decisions for individual controversial cases.

Table 2. (continued)

Location	Performance Zoning Provisions	Notes
Buckingham Township, Pennsylvania	The ordinance contains typical zoning districts but provides cluster and performance standard development provisions. It aims to preserve natural resources by clustering housing on the least environmentally sensitive areas.	Development of cluster and performance standards are "by rights," and as such, do not require public hearings. The sensitivity of natural areas makes the zoning more flexible in unrestricted areas but less flexible than most conventional zoning in placing restrictions for protecting natural areas.
Duxbury, Massachusetts	Two new categories of development (planned developments and cluster) were created in addition to existing traditional zoning. Both types are allowed in different portions of the town under a special permit process.	Termed "impact zoning," the ordinance aimed to create incentives for developers to build more diverse and environmentally sensitive housing. Developers are choosing standard subdivisions over the optional techniques to avoid lengthy and complex reviews.

Cost Considerations

Subwatershed planning for better site design zoning involves many costs. Mapping, photography, delineations, and involving the public are some of the items typically in such a budget (Table 3).

Table 3. Unit prices for subwatershed planning (Adapted from CWP, 1998)

Budget Item	Estimated Unit Cost	Assumptions
Aerial Photography	$500 per photo	Includes aerial flyover and developing of one color photograph.
Base Mapping	$500	For Subwatershed Management Map using USGS 7.5 minute Quad. Sheet. Includes, subwatershed delineation, overlaying land use, monitoring stations, and transportation routes.
Base Mapping	$5,000	For Aquatic Corridor Management Map, using aerial topography at 2' contour interval. Includes, aerial topography at 1" = 200', locating existing utilities, floodplain, wetlands, and riparian cover from existing maps (no field walk and no topo. survey control).
Floodplain Delineation	$5,000	Detailed analysis beyond FEMA, cross-sections plotted at 1000 ft on-center, topo spot-checked, road crossings evaluated, includes report, assumes flow data are available.
Geographic Information System (GIS)—start-up	$15,000	High end work station and software (e.g., ARC/INFO), includes approx. 2 weeks of training for operator. Does not include data layers
GIS—Obtain or Digitize Data Layers	–	Data layers include impervious cover, topography (5' C.I.), zoning, utilities, vegetative cover (broad categories)
Impervious Cover Measurement—Actual	$3,000	Uses digital orthophotography, impervious layer clipped at subwatershed boundary, algorithm to calculate impervious area

Table 3. (continued)

Budget Item	Estimated Unit Cost	Assumptions
Impervious Cover Estimation—Land Use	$600	Uses land use designations or zoning and measured areas compared against tables, requires review of aerial photo (not included) to estimate build-out.
Impervious Cover Projection—Based on Future Land Use	$800	Uses zoning or master plan and measured areas compared against tables, requires assessment of future build-out
Public Attitude Survey	$15,000 per survey	1000 homes contacted by telephone, includes survey questionnaire preparation and data analysis.
Stakeholder Involvement Program	$15,000	Plan and hold four public and four community meetings, direct mail to 20,000 people, staff time and direct expenses included.

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